Lunar CubeSat Software Architecture Analysis

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UNIVERSITY OF WASHINGTON LUNAR CUBESAT AVIONICS REPORT

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Overview

First CubeSat missions of their kind

New technological challenges not addressed in previous missions

Competition

- CalPoly is on CubeSat #8
- Vermont Tech has had a test launch

Vibrant research community!

Avionics Team

Previous quarter (Cosmo Harrigan, W15) HW research

- Radiation hardened components
- Processor suggestions, analyzed bit-flip probabilities

Software Architecture focus

- Core system
- Communications framework

Core System Requirements

High-availability OS (instant reboot, quick process restart etc.)

Per-process resource allocation

Lower power consumption

Support common data transference protocols

- TCP & UDP IP
- Unix/IPC Sockets
- I2C etc.

Continuous data capture and storage

Possible integration with hardware reset

- Watchdog timer?

Core System Architecture Features

Self-aware

- Priority 0 – system monitoring!

Process scaling

- Spin up/shut down processes
- Hierarchical process execution

Communications optimizations

- Software to batch-transmit pieces of data

Data processing and compression

- Compression software
- High-performance read/write

Communications System

VERY challenging compared to past missions

Perspective:

- Geostationary orbit – 1
- Low performance means low bitrate/higher packet loss
- Performance $\propto (1/\text{distance})^2$

Relative difficulty of 100

Serious problem

Solutions

Selective data compression

Compression algorithms

LOSSY COMPRESSION

Minor data loss

Used for non-vital data on most missions

NASA JPL developed image format

- ICER

LOSSLESS COMPRESSION

No data loss

Larger files

Vital data

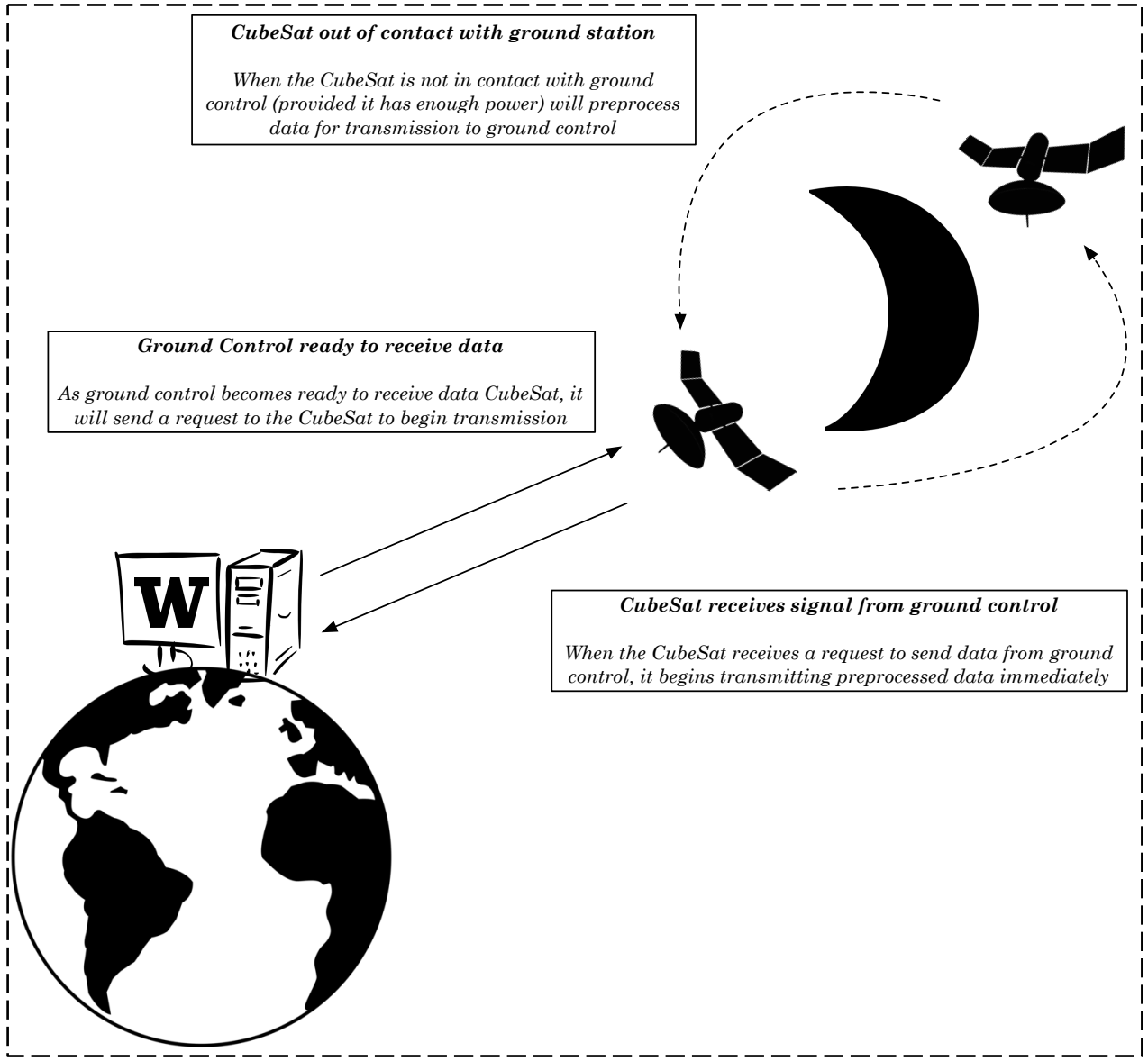
- Logs
- Instrument readings

Solutions

Selective data compression

- Combination of lossy and lossless compression
- Progressive compression

Client – Server request system


CubeSat out of contact with ground station
When the CubeSat is not in contact with ground control (provided it has enough power) will preprocess data for transmission to ground control
Ground Control ready to receive data
As ground control becomes ready to receive data CubeSat, it will send a request to the CubeSat to begin transmission
CubeSat receives signal from ground control
When the CubeSat receives a request to send data from ground control, it begins transmitting preprocessed data immediately

Solutions

Selective data compression

- Combination of lossy and lossless compression
- Progressive compression

Client – Server request system

- Reduced power consumption
- Used by phone companies, Martian satellites

Transmission redundancy measures

- Simple repetition coding
- Linear block coding

Questions?

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